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GLYPHOSATE TIMING EFFECTS ON DOWNY BROME (*Bromus tectorum* L.) SEED PRODUCTION IN SUMMER FALLOW

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INTRODUCTION

Control of downy brome (*Bromus tectorum* L.) in winter wheat presents a major constraint to the adoption of conservation tillage systems in the Pacific Northwest. Moldboard plowing, which deeply buries weed seed, has long been the conventional practice for managing downy brome. However, this practice is being limited by government mandates to implement conservation tillage programs which minimize soil erosion. Selective chemical control of downy brome in the winter wheat crop provides only partial suppression and is prohibitively expensive, particularly in drier, lower yielding cropland. For these reasons, it is necessary to obtain effective control through multiple year crop rotations, which include spring crops if feasible for a particular location.

Precipitation patterns vary greatly throughout the inland Pacific northwest and can make spring cropping a risky and unprofitable option for some growers utilizing currently available farming practices. Government mandates, economics, climate, and lack of control options all come together to complicate efforts to manage downy brome in the winter wheat/summer fallow crop production areas of Oregon, Washington, and Idaho.

Because it is difficult to manage downy brome in the growing wheat crop, it is particularly important to prevent downy brome growth and seed production during the summer fallow period. Effective control of downy brome during the fallow period helps deplete seed in the soil which reduces downy brome populations in the subsequent winter wheat crop. Delaying fallow tillage operations or herbicide applications in the spring increases the risk for production of viable downy brome seed during the fallow period.

A more precise understanding of reproductive development of downy brome, particularly in regards to when viable seed production occurs, could improve downy brome management through improved timeliness of downy brome control operations in fallow. Specifically, if the "cut-off" date for prevention of downy brome seed production was known, managers of large acreages could more effectively schedule field operations in fallow to prevent downy brome seed production. In addition, there is considerable uncertainty regarding the effectiveness of glyphosate (Roundup®) for preventing downy brome seed production if applied during later stages of downy brome floral development. Knowing the effective period for glyphosate application to prevent downy brome seed production based on growing degree days (GDD), a measure of heat units, could help facilitate control decisions.

Vegetative and reproductive developmental stages of winter wheat, and other grasses including downy brome have been related to GDD based on air temperature (Ball et al. 1993, Dotray et al. 1993, Klepper et al 1982, Klepper et al. 1994). Research indicates that the development rate for downy brome is more rapid than wheat, but the overall developmental relationships to GDD are very similar to wheat (Ball et al. 1993). Therefore, models for winter wheat growth could likely be modified to estimate dates of downy brome seed production. This predictive ability could provide wheat growers a tool to better time fallow operations for effective prevention of downy brome seed production between winter wheat crops.

This study was initiated to determine if downy brome seed production can be predicted by using cumulative GDD to determine when seeds become viable in the seed head development stage, and also to determine when herbicide applications need to be applied to prevent downy brome seed production.

METHODS AND MATERIALS

An experiment was established at the Columbia Basin Agricultural Research Station near Pendleton to determine the cumulative GDD required to obtain downy brome seed production, and to determine when downy brome needs treatment with glyphosate or paraquat in order to prevent production of viable seeds. The plot area which had previously negligible levels of downy brome was irrigated on October 3, 1993 and a fine seed bed prepared by rototilling before and after irrigation. A small plot drill with double disc drill openers was used to seed 5 rows of downy brome with 12-inch spacing on October 10 to a depth of about 0.5 inch into moisture. Individual plots were 6 ft x 12 ft with 4 replications. After seeding, two 1.6 ft emergence sites per replication were marked in the second and forth rows of 8 randomly selected plots. Observations of downy brome seedling emergence were made daily until emergence started, then counts of seedlings made every other day. The first emergence counts were made on October 24, 1993. After no further emergence occurred, the time of 50 percent emergence was calculated.

Climatalogical data collected at the site was used to calculate GDD by using the equation:

$$(\text{daily max. temp. - daily min. temp.}) \div 2$$

where daily maximum and minimum termperatures are in degrees Centigrade. The time required to obtain initial development of downy brome seed was related to GDD from 50 percent emergence and from January 1, a hypothetical starting date after vernalization of downy brome.

Downy brome plots were treated with glyphosate or paraquat at one of five timings starting at initiation of seed head emergence and continuing until early maturity (Table 1). Glyphosate rates of 8 or 16 fl. oz. of Roundup® per acre or paraquat at 1.5 pt of Gramoxone Extra® per acre were applied at each application timing. An untreated control was included to evaluate potential downy brome seed production. After maturity of downy brome seed heads, but before seed shatter, 30 panicles were collected per plot. Seed was separated from accessory material by gently rubbing intact seed heads on a textured rubber mat and collecting debris and seed. Collected, uncleaned seed from each plot was dry stored for several months then placed in wood flats containing a standard greenhouse soil mix, placed in a heated greenhouse, and watered to germinate downy brome seed. Germinated downy brome seedlings were counted from each flat at seven and fourteen days after planting and counts averaged for each treatment.

RESULTS AND DISCUSSION

By assuming that vernalization in the field is complete by January 1, it may be possible to use cumulative GDD from January 1 to time seed production. If this is a valid assumption, calculating GDD from January 1 would improve the ability to predict downy brome floral development since it is difficult to know when emergence actually occurs in commercial fields.

Downy brome seed heads began to emerge in plots on April 26, 1994, which was 801 GDD after January 1, or 1232 GDD from time of planting (Table 1). Application of glyphosate or paraquat at this time prevented production of germinable downy brome seed (Table 2). Delayed application of glyphosate at the lower application rate allowed partial recovery of treated downy brome plants resulting in some seed production, but at a much greatly reduced level compared to untreated control plants. Delayed application of the higher glyphosate rate until nearly 100 percent seed head emergence prevented viable seed production at 965 GDD accumulated from January 1 (May 10), and the delayed application of paraquat prevented viable seed production as late as 1047 GDD accumulated from January 1 (May 23). The more rapid burn-down of downy brome from paraquat application compared to glyphosate likely contributed to the prevention or reduction of downy brome seed production at the very latest application timings.

Table 1. Growing degree day accumulation at time of herbicide application, Pendleton, 1994.

Application Date	Growth Stage	GDD	50% GDD	Jan1 GDD
April 26	2% heading	1232	1101	801
May 3	20% heading	1312	1181	881
May 10	100% heading	1396	1265	965
May 23	full heading	1479	1347	1047
June 7	early maturity	1586	1455	1155
Seed Collection	maturity	1794	1663	1363

GDD - Growing degree days accumulated from planting, based on air temperature.

50% GDD - Growing degree days accumulated from time of 50% total downy brome emergence.

Jan1 GDD - Growing degree days accumulated from January 1, 1994.

Table 2. Herbicide timing effects on downy brome seed production, Pendleton, 1994.

Treatment	Rate	Timing	7 DAP	14 DAP
	fl. oz. /A		--seedlings/30 heads--	
glyphosate	8	2% heading	0	0
glyphosate	8	20% heading	66	87
glyphosate	8	100% heading	3	10
glyphosate	8	full heading	31	77
glyphosate	8	early maturity	829	1184
glyphosate	16	2% heading	0	0
glyphosate	16	20% heading	0	0
glyphosate	16	100% heading	0	0
glyphosate	16	full heading	5	22
glyphosate	16	early maturity	421	656
paraquat	24	2% heading	0	1
paraquat	24	20% heading	3	5
paraquat	24	100% heading	0	0
paraquat	24	full heading	0	0
paraquat	24	early maturity	55	178
control	-	-	2180	2180
LSD (0.05)			234	265

seedlings/30 heads - Number of seedlings emerged after planting seed collected from 30 heads per treatment.

% heading - Percent of plants with seed heads both partially and completely emerged.

Full heading - All seed heads completely emerged from boot.

DAP - Days after planting.

The above results indicate that late application of non-selective herbicides such as glyphosate or paraquat may be effective at preventing or greatly reducing downy brome seed production for some time after seed head emergence. This is not to say that it is desirable to wait until downy brome heading to treat with these herbicides. Late treatment increases the risk of seed production, requires higher herbicide application rates, and allows downy brome and other weeds to utilize soil moisture. However, these results suggest that effective control of downy brome seed production can be obtained soon after downy brome head emergence if conditions do not permit more timely herbicide applications.

This study will be repeated during the 1995 growing season to determine if viable seed production occurs at a GDD time similar to that observed in 1994. From the data collected in the current study, it appears that viable seed production began sometime after an accumulation of 1047 to 1155 GDD from January 1, based on downy brome response to glyphosate and paraquat treatment. Further experimentation will be conducted to more fully identify the time (in heat units) required for downy brome to produce viable seed. This information will be used to improve weed control recommendations for downy brome in winter wheat/summer fallow crop rotations.

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